Conference Reports

International Workshop on Assessing the Sustainability of Bio-based Products

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This workshop held on June 26 and 27, 2003 in Norman, Oklahoma (USA) gathered 44 experts from academia (14), government (10), industry (10), NGOs (3) and some from Europe (4) and Canada (2). It aimed to provide a forum to begin building a consensus about appropriate methods for assessing the impacts and sustainability of products, such as fuels and chemicals, made from biomass.

The use of biomass for energy and bio-based products is often touted as a means of achieving greater sustainability. However, this is by no means a universal view and questions have been raised about the benefits of bio-based products. The way one views the sustainability of bio-based products depends, in part, on how one frames the question of sustainability and the methods of assessment adopted.

The workshop structure included a series of presentations by leading researchers in the field, followed by facilitated breakout sessions. The presentations on the state-of-knowledge in bio-based product assessment gave participants a common starting point. The goal of the breakout sessions was to develop ideas on how to advance the assessment of bio-based materials. A broad mix of people from agriculture, manufacturing, and government, most with technical backgrounds and some with social science backgrounds, ensured that many perspectives would be taken into account. On the other hand, the breadth of representation enlarged and generalized the sustainability indicators for products that were ultimately identified.

Bio-based product sustainability – A three legged stool

The presentation session was opened by JOHN DORAN, who is a soil scientist with USDA Agricultural Research Service and professor of Agronomy at the University of Nebraska. He described bio-based product sustainability as a three legged stool: products must be economically viable, socially responsive and ecologically sound. The strategies for agricultural sustainability he outlined are conservation of soil organic matter through maintaining carbon and nitrogen balances with soil inputs always higher than outputs while minimizing soil erosion through reduction of tillage and crop residue retention. As a key indicator he proposes the direction of change in soil organic matter with time. He observed that in the past half century, efforts to meet traditional human demand for food, fuel and fibre through agricultural intensification have resulted in degradation of over 25 per cent of the world's agricultural land, pastures, woodlands and forest (Doran 2003).

Biomass – A vehicle for processing bio-based or conventional polymers

The second plenary speaker was TILLMAN GERNGROSS, Associate Professor at Dartmouth Collage and former head of fermentation process development at Metabolix Inc. He was the first but not the last to mention that biological processes and bio-based products do not automatically mean less use of non-renewable resources. He nicely illustrated this fact with a life cycle study of a biopolymer (polyhydroxylalkanoate or PHA) produced in genetically engineered corn that has been developed by Monsanto. He identified renewable energy as the key to 'green plastics' and showed the potential of using biomass not only as feedstock but also as a vehicle for processing bio-based or conventional polymers. A critical factor determining the life-cycle impacts of a bio-based product is the provenance of the feedstock; efforts should be aimed at minimizing impact while maximizing output. He sees the role of LCA as a tool to understand the tradeoffs involved in production decisions, but that does not solve the dilemma of competing value systems involving land use, national security, and emissions to air versus water. He concludes that LCA can help to formulate priorities and establish long-term strategies towards sustainability.

End of life of bio-based products

The talk of RAMANI NARAYAN, Professor of Chemical Engineering at Michigan State University focused on the end of life of bio-based products and clarified the relationship between bio-based and biodegradable. Not all the bio-based products are biodegradable and some petrochemical material is biodegradable. For the end of life of bio-based products there are four main concepts, composting, incineration, landfilling and recycling. Landfilling is problematic for bio-based products because of methane emissions during anaerobic degradation. Composting allows recycling a part of the carbon back to soil and incineration the recuperation of a part of the feedstock energy. Biodegradability is an advantage for products that are directly distributed in the environment such as films used in agriculture or chainsaw lubricants. But bio-based products cannot always claim biodegradability and compostability, nor environmental superiority. Discussion followed on the real environmental impacts and costs of composting, showing the need for further analyses in this domain.

State-of-art of LCA on bio-based products in Europe

OLIVIER JOLLIET, Professor at Swiss Federal Institute of Technology in Lausanne, presented the state-of-art of LCA on bio-based products in Europe. The introductory example about the use of popcorn as loose fill packaging outlined once more that 'natural' does not mean environmentally friendly and identified density as a key factor. A case study of a motorprotection underbody panel for automobiles manufactured with biofibers (Margand et al. 2003) showed advantages for the conventional panel in the production

phase but when the use phase is included the biofiber-based panels are much more environmentally friendly, because they can be lighter, reducing emissions throughout the vehicle life. Also described was a new approach for comparing different uses of biomass in biofuels, heat production and composites by looking at energy use and emissions per square meter of cultivated area, reflecting the use of biomaterials in terms of agricultural production (Ottaviani 2001). Conclusions are, we always have to consider the whole life cycle and material quantities are crucial especially in mobile applications. Careful checking of data and consistency in allocation procedures, substituted products and end-of-life treatments are required to ensure the quality and comparability of studies.

Sustainability of bio-based products

CARL MUSKA, Manager of Safety, Health and Environmental at DuPont Bioproducts represented industry in the plenary session and made workshop participants more aware of the company's perspective regarding sustainability of bio-based products. He showed results from the cradle-to-gate LCA case study of Sorona™, a biochemical fibre of polytrimethylene terephthalate (PTT) that is not yet commercialised. The PTT is derived in part from 1,3 Propanediol that is produced by genetically modified *E. coli* grown on dextrose derived from corn grain. At Dupont LCA is used for process development as the firm seeks to fulfil its commitment to sustainable production. It has been found to be a useful tool to evaluate alternatives, identify and prioritize improvement opportunities and focus on high impact areas.

Biomass-derived fuels

In his talk, JOHN SHEENAN of the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) presented an interesting overview of biomass-derived fuels, as examined in different LCAs carried out for the U.S. Department of Energy. Again, the source of the feedstock was determined to be of critical importance to the overall impact of bio-based fuels. For biodiesel, crop type is important, e.g. the reduced need for nitrogen fertilizer for soybean production can reduce related energy consumption and enhance the environmental profile. Sheehan presented LCA as an interesting tool for dialogue, across technical disciplines as well as part of the analytical-deliberative process of political decision-making. He said that involving stakeholders in such studies helps to sort out the uncertainties of the science from the uncertainties of the moral and ethical choices we need to make.

Biopolymers and biofibers

Several speakers referred to an excellent review of LCA studies on biopolymers and biofibers (Patel et al. 2003). Another review that should be of interest to researchers in this area is a summary of LCA studies on biomolecules, biomaterials, biofuels and energy crops now being performed by BONNARD & GARDEL and the Life Cycle Systems Group at Swiss Federal Institute of Technology in Lausanne for the French Environmental and Energy Management Agency. First results show biomaterials presenting high environmental benefits relative to biofuels. This review will be published in early 2004.

Priorities

In the breakout sessions an important agreement was found as far as priorities are concerned: products that present the highest environmental benefits in comparison with conventional products should be promoted first. It has been found once more that system definition is crucial and the assessment over the full life cycle is highly critical. Scale ('All biomass is local.' according to Bruce Dale) and dynamic assessment also play important roles.

The 'top 5' indicators of bio-based product sustainability identified were:

- Land Use / Soil Conservation
- Energy Flows (Density, intensity, quality)
- Social Issues / Vulnerability
- Economic Viability / System Profitability
- Climate Change / Greenhouse Gases
- Nutrient Cycles

Framework for assessment methods

The workshop participants set up a general framework for assessment methods. The detailed choice and specification of the most appropriate methods of assessment for the indicators requires further tests and comparison. Life Cycle Assessment for the environmental impacts was a nearly universal theme and there was also a clear consensus that we need to specify methods to assess economic and social impacts, the two other dimensions of sustainability.

Assessment techniques that were widely discussed include: involvement of stakeholders first and throughout; benefit cost analysis and risk assessment; backcasting; dynamic system analysis; and the use of geographical information systems. One important step towards a consistent assessment would be to set a research project with a common case study (e.g., a composite product involving transport and heat production) and have experts using different assessment techniques work in parallel on the same case to identify the critical sustainability issues, with a comparison workshop in the end.

We should then be able to answer grand questions such as: What kind of biomass and which products make best use of the limited land available for agriculture, and present the highest environmental, economical and social benefits when compared to conventional products?

The outcome of the workshop can now be distributed among participants and interested persons as a first proposition in the form of a concrete checklist on how to assess the sustainability of bio-based products.

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Proceedings: More information on the workshop, exemplary publications from the plenary speakers and proceedings can be found at: http://www.ou.edu/spp/biobased/workshop.htm